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ABSTRACT

The effects of three types of pacing in microcomputer-based instructional programs were examined by evaluating learning competency on five achievement tests ranging in difficulty from memorizing facts to solving problems. Subjects were 100 first-term freshmen enrolled at Ohio State University who completed a microcomputer program on heart physiology. Pacing levels were either: the self-paced program; an externally paced program, based on normal reading speed, plus cognitive processing time; an externally paced program, based on normal reading speed, without cognitive processing time; and the control group. (This group took the five tests, but received no instruction.) The learning tasks included a list learning task; a spatial learning task with cued-recall; a simple concept learning task; a complex concept learning task; and a spatial learning problem with free recall. Overall time to complete the instructional programs by each student was recorded, as well as the number of options for feedback on each subject working through the programs. Results favored moderate levels of external pacing. It was concluded that permitting students to interact in a totally self-paced instructional environment may not be the most effective method for facilitating student achievement for all types of microcomputer instruction. Eighteen references are listed. (LMM)

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Varied Self-Paced Micro-Computer Based Instructional Programs for Addressing Individual Differences When Acquiring Different Levels of Instructional Objectives

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Research Problem

The basic principle inherent in the design of micro-computer based instructional programs is the utilization of a self-paced instructional method. However, there are some indications that moderate levels of external and guided pacing may be more effective for learning in facilitating student performance levels, both in amount of content acquired, and instructional objectives levels attained. This hypothesis was tested in this study using three types of pacing, and evaluating learned competency on five achievement tests ranging in difficulty from memorizing facts to solving problems. Experimental results supported the hypothesis favoring moderate levels of external pacing, and concluded that the general assumption that permitting students to interact in a totally self-paced instructional environment, was not the most effective instructional method for facilitating student achievement for all types of micro-computer instruction.

Educational Technology and Attempts to Address Individual Differences

Researchers from a variety of different disciplines have considered the problem of learner individual differences and their influence on subsequent learning. A promising area of research which evolved to address individual differences of a cognitive nature was Aptitude Treatment Interaction (ATI) research. The general premise of the ATI effort was to propose fundamental predictions on how to design individual instructional treatments to address specific aptitude types (Cronbach, 1967; Cronbach and Snow, 1969). The ATI and Trait by Treatment Interaction research demonstrated that individual differences could be defined along the lines of a cognitive paradigm such as that proposed by Kagan, Moss and Sigel (1963). Each individual difference type could be characterized as a certain cognitive style, and varied instructional treatments might then be prepared to maximize the specific information processing capabilities of all the cognitive styles in a given group of students, in a given school curriculum. While theoretically valid, it does not take a great deal of effort to note that the practical aspects of such an instructional system would be tenuous at best. Unfortunately, the construct of individual learning differences remains a problem for teachers. Whether the individual difference variable is defined as genetic intelligence, as a cognitive style, or as an attitude, these individual difference characteristics have significant influences upon achieving various instructional objectives in the context of an academic learning environment. A more applied method of attempting to isolate and attend to individual differences has been through the design of instructional systems where learner control over the pace of instruction was permitted to vary as an independent variable. The value of self-paced instruction was pointed out by Carroll (1963) in his treatise defining aptitude as time required to learn to competency level. This treatise, of course, became the instructional system known as mastery learning (Block, 1971).

A number of other instructional systems have been designed around the idea of addressing individual differences by employing some type of an instructional system based upon learner control via self-paced instruction (Cross, 1976). The early research on programmed learning (Skinner, 1958)

was based on the empirical benefits of errorless learning, immediate feedback, and self-pacing. The Personalized System of Instruction (PSI) developed by Keller (1974), and the Individually Prescribed Instruction System (IPI) developed by Glaser (1968) both have as their basis the benefits of self-pacing. Similar to the PSI and IPI instructional methods, Postlethwait's Audio Tutorial System (1974) is an attempt to address individual learning difference by self-pacing. Early work in the area of CAI adopted the principles of programmed learning, and therefore attempted to accommodate for individual differences by self-pacing (Atkinson, 1968). As educational technology has now advanced to the utilization of micro-computer based instructional strategies, the conclusion regarding the benefits of designing micro-instructional systems to be self-paced, as a way of adjusting for individual learning differences, has been generally accepted by our field. However, there is some indication that external control may be more effective than learner control of pacing, in terms of learning achievement. For example, Gropper (1964) found that a fixed-paced method was more effective than self-paced alone. Similar results are reported by Reiser (1984), who found less procrastination in completing a learning task with a type of external control as opposed to complete learner control of progress pacing.

Arguments favoring moderate levels of external control of instructional program pacing can be found in Cognitive Psychology research, dealing with the psychological variables of attention and motivation. In discussing his generative learning model based upon current findings from cognitive psychology, Wittrock (1978, p.9) cites four key factors directly effecting learning: "(1) Semantic and abstractive processes in memory, such as schemata, rules, and algorithms; (2) distinctive or episodic memories, such as images or verbal memories; (3) attention, and (4) motivation." From Wittrock's position, two key elements directly affecting learning, at a cognitive information processing level, are attention and motivation. It is likely that locus of control over instructional program pacing will have a direct effect upon attending behavior and motivation, at a psychological information processing level. In other words, if moderate external pacing of an instructional program can increase attention and motivation at a basic psychological level, the learner should acquire more information in less time than in self-paced instructional programs. The Zeigarnick Effect and Ovsiankina Effect have revealed that increased levels of psychological motivation on problem solving tasks tend to improve memory and transfer beyond the original learning tasks (DeCecco, 1963). Similar effects on motivation and attending behavior are found with the Yerkes-Dodson Law (Travers, 1972), yielding results indicating that moderate levels of motivation improve memory and intellectual skill performance. It is likely that the self-paced instructional method may not be the most appropriate instructional approach for all possible applications of CAI using micro-computer based instruction, if attention and motivation are considered. In a recent literature review on the topic of learner control over instruction, Carrier indicated similar conclusions regarding amount and order of instruction (Carrier, 1984, p.17):

"Many CAI designers assume that by exploiting the technical capabilities of the computer, they can increase student learning. For at least one of these technical capabilities--allowing students to exercise their own judgment about how much instruction they need or in what order--this

assumption appears to be premature. There is little support from the research literature that offering students control will lead to increased learning (p. 17)."

The present study was conducted to test the experimental hypothesis that moderate levels of external pacing of a micro-computer instructional program would increase motivation and attending behavior and this would result in the more effective learning of instructional content, in terms of both the amount learned and level of competency performance using the learned content. A second hypothesis tested was that moderate levels of external pacing should improve the overall time efficiency of learning the instructional content. The third hypothesis was that higher achievers, as defined by the highest test scores on the five dependent measures, would opt for additional instruction, in the form of elaborate feedback, more than lower achievers on the five dependent measures. The third hypothesis would indicate that lower achieving students may not be in a position to opt for more instruction, but may require being forced into an elaborate feedback loop after a series of errors.

Experimental Design and Procedures

To test the first experimental hypothesis, a 4x5 Lindquist Type-I analysis of variance was used, having four between subjects levels and five within subjects levels. The between subjects factor was type of external pacing of the micro-computer instructional program, and its four levels were:

1. Self-paced program (SP),
2. Externally-paced program, normal reading speed, plus Cognitive processing time (EP+Cp)
3. Externally-paced program, normal reading speed, no Cognitive progressing time (EP-Cp),
4. Control.

The within subjects factor represented different levels of instructional objectives, defined as learning tasks. There were five levels of learning task, and they were called:

1. List learning task
2. Spatial learning task, Cued-recall
3. Simple Concept learning task
4. Complex Concept learning task
5. Spatial learning problem, free recall

The second hypothesis was tested by collecting time data on overall time to complete the instructional programs by each subject and averaging across subjects. This data will be presented descriptively. The third hypothesis was tested by collecting the number of options for feedback on each subject working through the instructional programs. The top six test scores, in each pacing condition, were then defined as higher test achievers, and the low six test scorers in each pacing condition, were defined as lower test achievers. An analysis of variance was conducted

between the high achievers opts for feedback and the low achievers opts for feedback, at each level of instructional program pacing.

Each of the three micro-computer instructional programs was designed to teach subjects about the parts and operation of the human heart during systolic and diastolic functioning. The instructional content was an adaptation of the original Dwyer (1967) stimulus materials. The instructional content in each of the three instructional programs and sequence of content was identical. Each instructional program contained 57 instructional segments which consisted of one or two frames (individual computer displays) of instruction describing the heart parts and heart functions. Each frame of instruction consisted of a visual with a verbal description and arrow, or arrows, pointing out the important information in that display. There were three types of visuals used in the instructional programs (Figure 1). Each instructional display consisted of some combination of one of the visuals and a verbal explanation (Figure 1). Each of the three micro-computer instructional programs making up the external pacing factor will be described in detail. The graphics and text were authored using Apple SuperPILOT. Verbal instruction was presented in each program, at a normal reading speed, (300 words/min.) although two programs are externally paced at the point of instruction and elaborate feedback.

(1) Self Paced Instructional Program

The SP instructional program is self-paced at the point of instruction and feedback. Each of the 57 instructional segments start with the heart drawing, then part or phase names appear, then an arrow, or arrows, followed by the instructional text. After each completed instructional display is generated, the learner has as much time as desired to study the instructional display. To move on, the learner presses the return key to receive an activity question. The instructional display is removed prior to the presentation of each of the 57 activity questions. The learner responds to the activity question by typing in the correct response. The program accepts not only the standard spelling for correct answers but plausible misspellings as well. If the correct response is entered, correct feedback is given in the form of simple feedback (i.e. right, correct, got it, etc.). If an incorrect answer is typed in, simple feedback is given that the response is incorrect. The student is then given the option of receiving elaborate feedback, which is the repeat of the instructional display. However, this feedback is completely optional; he or she can move to the next instructional display without feedback. A record was kept for each subject on the amount of feedback options taken. Both the instructional display and the elaborate feedback aspect of the instructional program were completely self-paced.

(2) Externally Paced Program plus Cognitive Processing Time

The EP+Cp instructional program is externally paced at the point of instruction and elaborate feedback. The 57 instructional displays are identical to the SP instructional condition; containing the same content, in the same order, with each display generated in the same way, and at the same rate. However, the external pacing begins after the instructional display is completed. After each instructional display is completed, the program times the student's interaction with the completed display at a

pace of: (a) 1 second per each line of verbal instruction, plus 1 second; so for 5 lines, 6 seconds for reading are given; (b) 7 seconds for cognitive processing are then given, after 1 second per line, plus 1 second, time has elapsed;(c) after reading time and cognitive processing time has elapsed, the instructional display is removed from the terminal screen. To move ahead, the learner presses the return key to receive the activity question. The learner has as much time as required to respond. If the correct answer is entered, simple feedback is given and the student moves to the next instructional display. If the incorrect answer is typed in, simple feedback is given that indicates an incorrect answer. As in the SP condition, the learner is given the option of receiving elaborate feedback, which is the repeat of the instructional display containing the required answer. The elaborate feedback is optional; the learner can move to the next instructional display or take feedback. Feedback is a repeat of the instructional display and is timed the same way, not allowing self-paced elaborate feedback. Therefore, in the EP+Cp instructional program, both instruction and elaborate feedback are externally paced.

(3) Externally Paced, No Cognitive Processing Time

The EP-Cp instructional program is externally paced at the point of instruction and feedback. The 57 instructional segments are identical to the SP and EP+Cp instructional conditions; containing the same content, in the same order, with each display generated in the same way, and at the same rate. After each instructional display is completed, the program times the learner's interaction with the now completed display at a pace of:

(a) 1 second for each line of verbal instruction, plus 1 second (i.e., 5 lines of written instruction, 6 seconds of interaction allowed).

(b) After interaction time of 1 second per line plus 1 second passes, the instructional display is removed from the screen.

(c) Cognitive processing time of 7 seconds is not allowed in the EP-Cp instructional condition.

The 57 activity questions in the EP-Cp instructional condition are identical to the SP and EP+Cp conditions. The learner has as much time as needed to respond to the activity questions. As in the SP and EP+Cp conditions, simple feedback is given after the learner responds to the activity question. If an incorrect answer is given, the learner has the option of receiving elaborate feedback, or moving to the next frame of instruction. The elaborate feedback is a repeat of the instructional display containing the correct answer. However, the elaborate feedback is externally paced in the same way as the instructional display, thus not allowing self-pacing at the point of instruction and elaborate feedback.

(4) Control

To determine the base rate of the subject's pre-instructional program knowledge of heart physiology, a control group was randomly formed from the pool of 100 subjects participating in the study. The control group took the five tests, but received no instruction. The control group method was used, as opposed to a pre-test for all subjects, because it was felt that a pretest would serve as an advance organizer, and therefore add an unwanted intervening variable to the study.

The within subjects factor represented the different levels of objectives, or learning tasks, and consisted of the five achievement tests to evaluate the amount of information acquired and competency level with learned information. To do this, the five tests ranged in difficulty from a simple memory task to a more difficult problem solving task. Each of the five tests contained a total of 20 possible points, and will be described according to level of intellectual difficulty, simple to difficult.

(1) List Learning Task
The list learning task was a simple memory task, requiring the learner to list the names of the parts of the heart.

(2) Spatial Learning Task, Cued-Recall
The spatial learning task, cued-recall, consisted of 20 multiple choice items designed to test the spatial learning of heart part location. The test contained a line-drawing of the heart with numbers and arrows indicating where each part was located. The 20 test items appeared under the numbered drawing and required the subject to identify specific part locations.

(3) Simple Concept Learning Task
The simple concept learning task contained 20 multiple choice items. Each item provided in the item stem a description of a critical attribute about a heart part or operation. The learner selected the heart part or operation from the available choices.

(4) Complex Concept Learning Task
The complex concept learning task contained 20 multiple choice items. The items were complex in the sense that they involved "if-then" relationships of the parts of the heart during heart operation, or what could be defined as disjunctive concepts.

(5) Spatial Learning Problem, Free-Recall
The spatial learning problem, free recall was considered the most difficult of the five tasks. The learner had to prepare from memory a line drawing of the heart, with the parts in the correct location and labeled. Then the learner had to indicate blood flow through the heart pump system, by drawing a series of dotted lines connecting how the parts interact during heart operation.

Subjects participating in the study were first term freshmen enrolled at Ohio State University. There were 100 subjects that participated in the study, and they received course credit towards their final grade in freshmen psychology for their participation. Subjects were randomly distributed by the experimenters to the three instructional program conditions and the control. Each instructional program group had 25 subjects, and the control group contained 25 subjects. The control group took the five achievement tests the day before the rest of the study was conducted to establish a base rate on the subject pools' knowledge of heart physiology. As can be seen in Table 1, part II, the control failed to know the names of the parts of the heart or the heart part locations and functions. The controls acquired score on the three multiple choice tests is a function of random guessing. As can be seen by the controls overall average score of (4.43) points on the five achievement tasks, they were

only able to score an average of (22%) across all tasks. Based on this result, it was determined that the subject pool had little prior knowledge of heart physiology. The study was conducted during the following day. Three two-hour time periods, over a period of one day, were blocked off for each of the three instructional program types, beginning with the SP group, followed by the EP+Cp group, and then the EP-Cp group. All three groups were given instructions that they would be working through a micro-computer instructional program on heart physiology. The groups were not aware of any differences in the programs, nor were they aware that opts for feedback and overall time for instructional program completion were being monitored. After these simple instructions were given, the subjects went to the micro-computer lab to work through their instructional programs. When they completed their instructional program, they returned to the classroom to take the five achievement tests. The two free recall tests were administered first to avoid subjects attaining cues from the multiple-choice tests. After completing the two free recall tests, the three multiple-choice tests were administered.

Resulting Data

Analysis of the resulting experimental data from the Lindquist Type-I design appears in Table I, part I, and the between subjects mean, within subjects mean and simple effect means are presented in Table I, part II.

The analysis of variance results in a significant F-ratio on the between subjects variable of instructional program pacing, [$F(3,96\ Df) = 45.875$, p .001]. A Tukey follow-up test was conducted on the between subject means, with a significance level set at (.05). The three experimental group means [(SP,$\bar{X}$=10.57)(EP+Cp,$\bar{X}$=12.22)(EP-Cp,$\bar{X}$=9.02)] differ significantly from the control [C,$\bar{X}$=4.43]. The EP+Cp mean [$\bar{X}$=12.22] differs significantly from the EP-Cp mean [$\bar{X}$=9.02]. However, while the EP+Cp mean did not differ significantly from the SP mean, the EP+Cp mean is greater. The SP mean does not differ significantly from the EP-Cp mean.

The within subjects variable of task difficulty resulted in a significant F-ratio; however, there was a significant interaction between instructional program pacing and task difficulty [$F(12,384\ Df)=10.485$, p .001]. To find the source of the interaction a Tukey follow-up test was used, set at a significance level of (.05). The significant interaction is graphically displayed in Figure 2. The source of the interaction is found in the EP+Cp instructional program condition. In the EP+Cp condition, as task difficulty increased across the first four achievement tests, the performance competency of the EP+Cp subjects remained constant. Even at the most difficult achievement test level, the spatial problem, the EP+Cp group performed significantly better than the EP-Cp group, and slightly better than the SP group. The SP group had a significant decrease in performance competency as task difficulty increased, yielding a significant decrease in performance between the complex concept task [$\bar{X}$=10.40], list learning task [$\bar{X}$=12.36], and spatial learning task, cued recall [$\bar{X}$=12.32]. Similar results occurred with the EP-Cp condition, finding a significant drop in performance between their list learn task mean [$\bar{X}$=11.84], and simple concept task and complex concept task means [($\bar{X}$=8.88);($\bar{X}$=9.48)].

Additionally, at the EP-Cp level, the spatial learning, cued-recall task mean [$\bar{X}$=10.64] differed significantly from the simple concept task mean [$\bar{X}$=8.88], and their performance competency on the spatial problem was quite low [$\bar{X}$=4.28].

The significant interaction finds support for the first hypothesis, indicating that moderate levels of external pacing of a micro-computer instructional program tended to allow for more content information to be attained, and allowed for a higher level of competency performance with learned information over a self-paced instructional program. Support is found for the second hypothesis, indicating that an externally paced instructional program would allow for more efficient learning than self-paced alone. Looking at the average time for completion of the three instructional programs (Table 1, part II) finds the EP+Cp group to be more efficient than the SP group [EP+Cp=44.64 min.; SP=50.36 min.; EP-Cp=45.04 min.].

In many micro-computer instructional programs, the learner is permitted to opt for elaborate feedback in the form of additional instruction. However, it is likely that higher test achievers will tend to opt for elaborate feedback more often than lower test achievers, even though lower achievers actually need the elaborate feedback or additional instruction more than their higher achieving counterparts. This, of course, would indicate that learner control over needed additional instruction may not be appropriate. The third hypothesis was tested by comparing opts for feedback of higher achievers on the five tasks, as defined by the six subjects having the highest test scores in each pacing condition, and the lower achiever opts for feedback. Lower achievers were defined as the six subjects in each instructional pacing condition with the lowest achievement test scores. An analysis of variance was conducted comparing opts for feedback between higher achievers and lower achievers, at each of the instructional pacing conditions. The resulting analysis is summarized in Table 2. A significant F-ratio occurred on the feedback opts variable [F(1,30 Df)=192.47, p .0001]. This result supported hypothesis three, finding that those subjects defined as higher achievers selected elaborate feedback, ($\bar{X}$=86.56%) of the time, when an error was made on an activity question during instruction. Those subjects defined as lower achievers selected elaborate feedback ($\bar{X}$=29.72%) of the time, when an error was made on an activity question during instruction.

Discussion of Resulting Data

Results of the present study indicate that self-paced instructional methods for micro-computer based instructional programs (MCBI) may not always be the best method of addressing individual learning differences. The decision is often made by instructional specialists working with MCBI to build instructional programs to be self-paced, simply because the micro-computer is well adept at self-pacing. Additionally, many of the past efforts at accommodating for individual learning differences, have been to design instructional systems around the relative benefits of self-pacing (Cross, 1976). However, when considering a cognitive psychology paradigm of improving learning, the variables of attention and

motivation should not be ignored. Since attending behavior and motivation are key psychological elements in the learning process (Wittrock, 1979), it is likely that by manipulating these variables, learning outcomes can be changed.

The present study demonstrated that during a self-paced instructional program subjects behaved differently, in terms of amount learned and performance competency with learned material, than subjects in a moderate externally paced instructional program condition. It is likely that this element of moderate external pacing caused subjects in this condition to be more motivated to interact with each instructional display and attend to information in each display more carefully. The EP+Cp instructional program condition caused a significant increase in learning and performance competency, even on the more difficult tasks. This result indicates that moderate levels of external pacing can improve overall learning, and that self-pacing may not always be the best methodology for MCBI. However, learning performance was significantly impaired by eliminating the 7 seconds of cognitive processing time in the EP-Cp instructional program condition. Apparently, this slight change in pacing increased motivation to a point where cognitive information processing deteriorated. This fits the Yerkes-Dodson Law quite well (Travers, 1972), and indicates that moderate external pacing is defined as external pacing allowing a reasonable amount of time for mental interaction with the generated instructional display. In other words, external pacing can increase attending and motivation resulting in improved learning, but it cannot be too extreme.

On the issue of opting for elaborate feedback, or additional instruction, it would seem that the students that may need elaborate feedback the most, are those less likely to opt for it. This result fits Carrier's (1984) conclusion that students may not be the best judges of what instruction they need, and how much instruction they need, for effective learning to take place. However, many instructional designers build MCBI programs that may have elaborate feedback available, but only recommend to learners that such feedback is needed. It may be necessary to force learners into elaborate feedback loops, or remedial instruction loops, if they are making a significant amount of errors on activity questions or instruction post tests.

Conclusion

The purpose of this study was to investigate the axiom that when learners are permitted to interact with self-paced instructional materials, for as long as is perceived necessary to acquire academic content materials, learning will be optimum. Results obtained from this study provide evidence which indicates that when students are permitted to exercise freedom through instructional sequences, learning is not optimized. The data also yields evidence which shows that varied types of self-paced micro computer instructional strategies are not equally effective in facilitating student achievement of identical instructional objectives. Further, these results indicate that complete learner control over feedback, for micro computer instructional programs, should be used with caution since one cannot assume that students who require further

instruction will actually engage in further instructional work via branching options or elaborate feedback options.

External pacing of MCBI applications should be investigated further, using different types of academic content and different types of instructional objectives. Additionally, a variety of external pacing methods should be considered for MCBI learning systems, and the effect of these methods should be evaluated on learners with different cognitive styles (i.e., field-dependents-independents, reflectives-impulsives, etc.).

WHOLEHEART!

HEART

CONTRACT!

Each half of the heart is divided into an upper chamber and a lower chamber. The upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides, both sides function simultaneously.

Figure 1: Heart Visual Types, and Sample Instructional Display.

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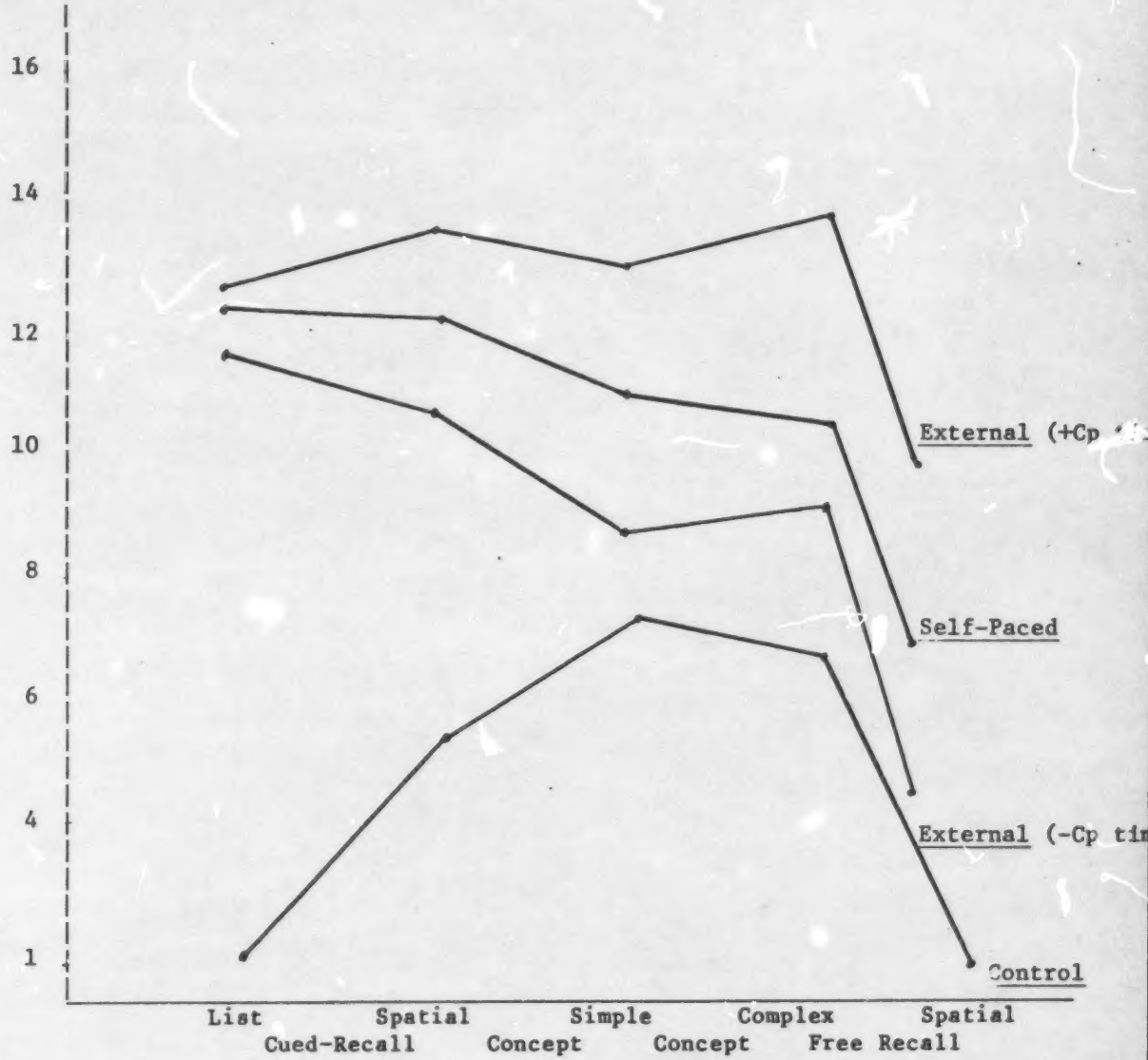

Figure 2: Graph of Significant Pacing by Learning Task Difficulty Interaction

Source	Mean Sq.	Df	F-ratio	Probability
BETWEEN GROUPS				
Pacing (A)	1404.359	3	45.875	.001
Error	30.613	96	--	
WITHIN GROUPS				
Learning Task Diff (B)	493.917	4	99.785	.001
(A) x (B)	51.901	12	10.485	.001
Error	4.949	384	--	

Table 1, Part I: Lindquist Type-I Resulting Data.

	Self-Paced	External Pace, Norm Reading Speed + Cp	External Pace No Cp	Control	WG, $\bar{X}$.. Control In
List Parts (List Learning)	12.36	12.48	11.84	1.92	9.65
Spatial Learning, Cued-Recall	12.32	13.60	10.64	5.68	10.56
Simple Concept Learning	11.00	12.80	8.88	7.12	9.95
Complex Concept Learning	10.40	13.64	9.48	6.56	10.02
Spatial Learning Problem, Free-Recall	6.76	8.60	4.28	.88	5.13
BG, $\bar{X}$ ..	10.57	12.22	9.02	4.43	
Avg. Time Overall	50.36 min.	44.64 min.	45.04 min.	n/a	

Table 1, Part II: Resulting Means and Overall Time to Complete Instructional Program

Source	Mean Sq.	Df.	F-ratio	Probability
Between Groups				
Pacing (A)	241.861	2	1.6	.22
Feedback Opts (B)	29070.25	1	192.47	.0001
(A) x (B)	86.583	2	.57	.57
Error	151.039	30		

Significant Means High 6 vs. Low 6:
Feedback Opts, High 6 ($\bar{X}$=86.56%),

Feedback Opts, Low 6 ($\bar{X}$=29.72%)

Table 2: Anova results on feedback options of hightest scoring 6 and lowest scoring 6 and significant means.

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